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MONITORED PERFORMANCE OF AN INNOVATIVE MULTI-UNIT RESIDENTIAL BUILDING

Introduction

In 1998-99, an innovative, 6 storey, 48 unit condominium was designed and constructed around the four main goals of the Canada Mortgage and Housing Corporation's IDEAS Challenge and Natural Resources Canada's C-2000 programs. These include envelope durability, energy efficiency, indoor air quality (occupant health), and environmental and resource conservation. The building was designed to have energy consumption 35 per cent lower than a similar building designed to meet the Canadian Model National Energy Code for Buildings. The thermal comfort and indoor air quality were also designed to be better than that in typical apartment buildings.

Many advanced, or innovative features were integrated into the design and construction of the building. These included:

- an airtight and well-insulated building envelope using both Exterior Insulating Finish System (EIFS) and brick veneer cladding. Thermal bridging through the building envelope by floor slab brick ledges and balconies was eliminated.
- Window features included Low E, spectrally selective, argon filled, insulating spacers and fiberglass frames.
- individual metering for natural gas and electricity
- natural gas-fired combination space/water heating in each suite (Figure 1). The in-suite fan-coil units utilize high efficiency electronically commutated motors for low energy consumption
- individual in-suite and separate common area heat recovery ventilation systems
- corridor air heat recovery ventilation that used the garbage chute as a return air plenum



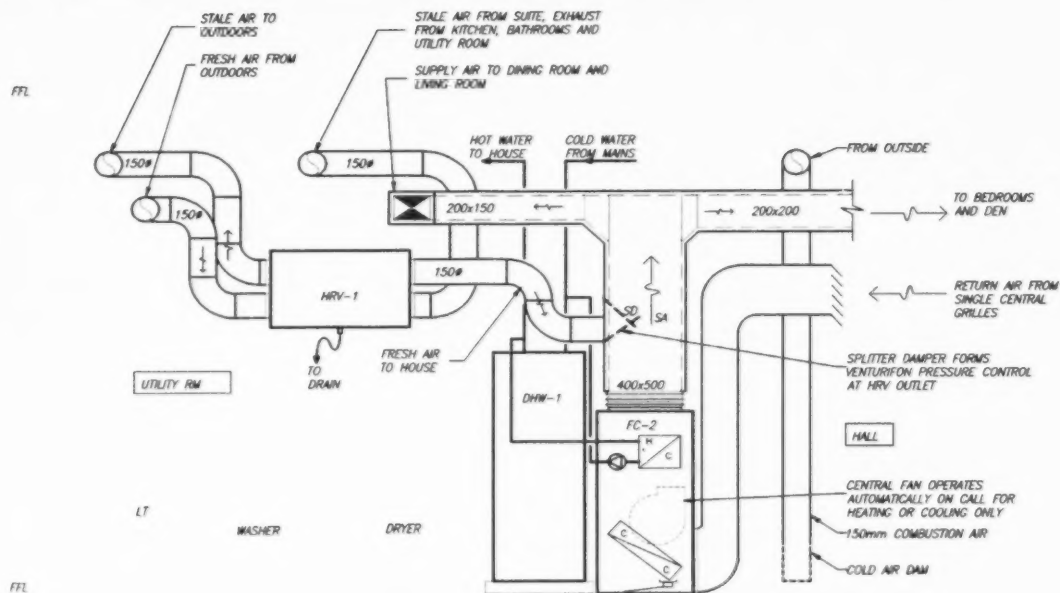
- water efficient appliances and fixtures
- energy-efficient appliances and lighting in common areas and parking garage.

While it is one thing to design such features into a building, there has been little follow up work done to determine whether or not buildings that have incorporated advanced technologies actually achieve their goals. Accordingly, Canada Mortgage and Housing Corporation initiated a research project to evaluate the performance of the building in terms of energy and water use, indoor environment, and building envelope durability.



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Figure 1: Combination In-Suite Space, Domestic Hot Water and ventilating System



Research Program

In order to characterize the performance of the building, an extensive monitoring program was developed by the project consultant, Enermodal Engineering Limited. The monitoring program for each performance area was as follows:

1. Building Envelope Air Leakage Control

A program was developed to ensure that the building envelope was designed and constructed to meet a minimum performance criteria of $1.0 \text{ L/s/m}^2 @ 75\text{Pa}$. This criteria was selected as it is roughly 1/3 to 1/4 the air leakage rate of typical multi-unit residential buildings. The project consultants evaluated the building plans and identified areas where air sealing details had to be developed. Once the air leakage details were created, a quality assurance plan involving trades training, site inspection and airtightness testing was instituted. The airtightness testing involved the testing of isolated wall areas, entire apartments and, finally, the complete building envelope.

2. Energy and Water Consumption Monitoring

The natural gas, electricity and water consumption for the common areas and suites were monitored via the utility meters for the first year post occupancy. Detailed energy consumption patterns were monitored

continuously in 3 suites and a common area to characterize the performance of the combination space and water heating systems, high efficiency furnaces and domestic hot water tank (used in one suite) and boilers used in the project.

The energy and water monitoring was used to identify monthly and yearly consumption so that the degree to which the performance targets were met could be assessed. The information was useful to identify the energy performance of combination space and domestic hot water heating systems used in multi-unit residential buildings. The energy data was also used to compare the performance of the building to other multi-unit residential buildings.

3. Ventilation System Performance

The performance of the in-suite heat recovery ventilation systems were assessed via flow measurements and long term PFT tests from Brookhaven National Laboratory and short term instantaneous SF6 tracer gas decay tests. The objective of the tests was to determine the ability of the HRV systems to exchange, distribute and circulate ventilation air in the apartments. The performance of the parking garage and corridor ventilation system was also assessed via tracer gas tests to determine whether or not they effectively ventilated these areas and prevented the proliferation of air from these zones to other areas of the building.

4. Indoor Environment

The indoor environment in one suite was monitored for air borne particulates, formaldehyde, and volatile organic compounds. Long term monitoring of temperature, relative humidity and carbon dioxide was also performed in 3 suites. The objective of these tests was to determine if the measures taken to provide an enhanced quality of indoor air were successful.

5. Heat, Air and Moisture Performance of the Wall Assemblies

The temperature, moisture and pressure regimes through the brick veneer and EIFS wall sections were monitored continuously to determine if conditions in the wall assemblies were conducive to long term durability.

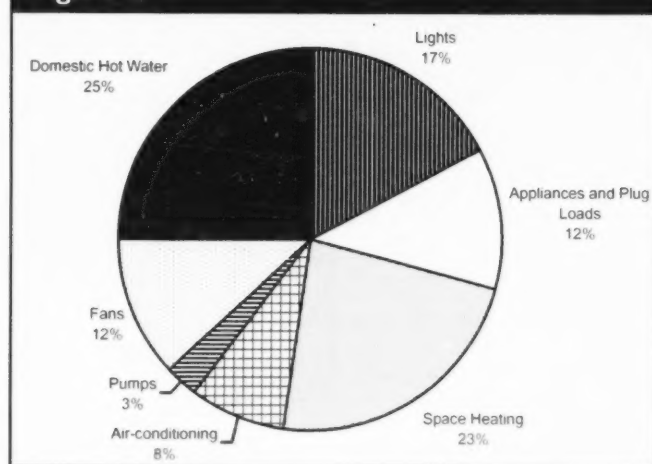
The monitoring program took place once the building was fully occupied for the period of one year. Most of the monitoring was done automatically with on-site instrumentation and data recording equipment.

Findings

In general, the overall performance of the building met with expectations. Some of the major findings of the performance assessment testing and monitoring were as follows:

- The building consumed 137 ekWh/m² for the year monitored. While this was in excess of the performance target of 125 ekWh/m², it is still far below the Model National Energy Code for Buildings value of 195 ekWh/m² and the "typical" annual energy consumption of multi-unit residential buildings that can be in excess of 300 ekWh/m². Figure 2 shows the distribution of annual energy use in the building.

Figure 2



- The seasonal energy efficiency of the combination space and domestic hot water heating systems was found to range between 43 per cent and 63 per cent. The low efficiency was thought to be a function of inadequate commissioning practices and low space heating and domestic hot water loads.
- The average electrical base load per suite was 11.8 kWh per day. When the space cooling load is included, the average electrical load is 15 kWh per day. The average natural gas use, for space heating and domestic hot water, averaged 2.6 m³ per day per suite.
- The central cooling system consumed 61,610 kWh during the monitored year or 1,162 kWh per suite.
- Water consumption, metered centrally, indicated a water use of 77m³ per suite per year or 0.5 m³/m²/year. This represents very little water use when compared to other multi-unit residential buildings. The low consumption is likely due to the water saving appliances (toilets and faucet aerators) and the building being populated by affluent seniors who can spend the winter months away.
- The building envelope airtightness target was met despite the challenges of integrating air leakage control procedures across the many stages of design and construction and the many different trades that must be convinced to buy-in to the process. The improved building envelope no doubt contributed to occupant comfort and low space heating energy consumption. The level of airtightness achieved in this project represents a reduction of 75 per cent over conventional buildings.
- The heat, air and moisture monitoring of the wall assemblies found the condensation potential within the walls to be low. This should help to ensure the long term durability of the wall structures.
- The in-suite heat recovery ventilation units were found to operate in an effective manner. The tracer gas tests showed that ventilation air is well distributed and circulated in each apartment—something rarely achieved in conventional apartment buildings. The testing also showed that the HRVs could distribute and circulate ventilation air without the operation of the forced air system fan thereby representing an electricity saving option.
- The corridor ventilation system, that delivered air to the corridors and exhausted air from the garbage

chute was found to help contain garbage chute odors, prevent the proliferation of parking garage gases to the apartments and maintain acceptable air quality conditions in the corridors of each floor.

- The indoor air quality monitoring in one apartment found common contaminants to be within Health Canada guidelines. Indoor air temperatures in 3 apartments were held fairly constant during the space heating and cooling seasons. Indoor relative humidity in the 3 apartments varied from 15 to 70 per cent but average summertime RH ranged from 40 to 60 per cent while the average winter range was 25 to 40 per cent. Carbon dioxide readings averaged between 516 and 827 ppm but with occasional readings of up to 2,000 ppm. The in-suite HRVs appeared to maintain good IAQ.

Implications for the Housing Industry

The verified performance of this innovative multi-unit residential building indicates that it is possible to integrate many advanced and environmentally responsible features into a fairly conventional construction project. The successful integration of an air leakage control procedure into the construction, design and commissioning process is perhaps one of the most important aspects of this project. The in-suite and corridor ventilation strategies represent significant departures from conventional designs but demonstrate significantly improved performance.

The study also shows that the energy use, hence environmental impact, of multi-unit residential buildings can be significantly reduced through thoughtful design and construction techniques without risk to the commercial viability of the project.

Project Manager: Duncan Hill

Research Report: *Monitored Performance of an Innovative Multi-Unit Residential Building, 2002*

Research Consultant: Enermodal Engineering Limited
Waterloo, Ontario

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or contact:

Canada Mortgage and Housing Corporation
700 Montreal Road
Ottawa, Ontario
K1A 0P7

Phone: 1 800 668-2642

Fax: 1 800 245-9274

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